

Table 3-14. Summary of maximum concentrations of neptunium-237 in soil moisture and perched-water samples from the Radioactive Waste Management Complex from FY 1997 through 2002.^a

Sampling Range (feet below land surface)	Fiscal Year ^b	Maximum Concentration $\pm 1\sigma$ (pCi/L) ^c	Sample Location
Lysimeters 0 to 35 ft	1997	NA	—
	1998	NA	—
	1999	NA	—
	2000	ND	Various ^d
	2001	ND	Various ^d
	2002	ND	Various ^d
Lysimeters 35 to 140 ft	1997	NA	—
	1998	NA	—
	1999	NA	—
	2000	ND	Various ^d
	2001	ND	Various ^d
	2002	ND	I4D-DL14, O8D-DL29
Lysimeters >140 ft	1997	NA	—
	1998	NA	—
	1999	NA	—
	2000	NA	—
	2001	NA	—
	2002	NA	—
Perched-water wells >140 ft	1997	NA	—
	1998	NA	—
	1999	NA	—
	2000	ND	USGS-92
	2001	ND	USGS-92
	2002	ND	USGS-92

a. MCL = 15 pCi/L total alpha activity concentration.

b. Fiscal year spans from October 1 to September (e.g., October 1, 1996, to September 30, 1997, is FY 1997)

c. NA = Not analyzed. ND = Not detected.

d. Various locations were sampled.

FY = fiscal year

MCL = maximum contaminant level

Table 3-15. Maximum concentrations of neptunium-237 in Radioactive Waste Management Complex aquifer wells from FY 1997 through 2002.^a

Fiscal Year ^b	Maximum Concentration $\pm 1\sigma$ (pCi/L) ^c	Well Location
1997	NA	—
1998	NA	—
1999	ND	Various ^d
2000	ND	Various ^d
2001	ND	Various ^d
2002	0.38 \pm 0.04	A11A31

a. MCL = 15 pCi/L total alpha activity concentration.

b. Fiscal year spans from October 1 to September (e.g., October 1, 1996, to September 30, 1997, is FY 1997).

c. NA = Not analyzed. ND = Not detected.

d. Various locations were sampled.

FY = fiscal year

MCL = maximum contaminant level

3.7 Plutonium

All plutonium isotopes are anthropogenic and TRU products of nuclear reactor operations or nuclear weapons production, deployment, and testing. Approximately 1.71E+04 Ci of Pu-238 were disposed of in the SDA, primarily from INEEL reactor operations waste. Approximately 6.48E+04 Ci of Pu-239, primarily from RFP, were disposed of in the SDA. Approximately 1.71E+04 Ci of Pu-240 were disposed of in the SDA, primarily from RFP with a significant portion from INEEL reactor operations.

3.7.1 Waste Zone

Two waste zone soil moisture samples were collected and analyzed for Pu-238 and Pu-239/240 in FY 2002, with two positive detections of Pu-239/240 (see Table 3-16). Samples were collected from Lysimeter 741¹08-L1, which is located in the Americium/Neptunium Focus Area in Pit 10. The Pu-239/240 results reported in Table 3-16 exceed the 1E-05 risk-based concentrations (RBC) for drinking water.

Table 3-16. Plutonium-239/240 detections in Subsurface Disposal Area waste zone soil moisture (lysimeter) samples.

Lysimeter	Depth (ft)	Sample Date	Sample Volume (mL)	Radionuclide	Sample Concentration $\pm 1\sigma$ (pCi/L) ^a	MDA ^b (pCi/L)	RBC ^c (pCi/L)	Sample Identifier	Limitations and Validation Report Identifier
741-08-L1	15.2	11/7/01	~15	Pu-239/240	35 \pm 10	11	3.5	IPL006013A	DNT-060-02
741-08-L1	15.2	4/29/02	~20	Pu-239/240	37 \pm 12	16	3.5	IPL057013A	SOS-019-02

a. Red bold font indicates the sample concentration exceeds the 1E-05 RBC.

b. The MDA is commonly referred to as the detection limit, and is a unique to each individual sample analysis result.

c. The RBC for drinking water does not apply to soil moisture samples, and is provided only as a basis for comparison.

MDA = minimum detectable activity

RBC = 1E-05 risk-based concentration

Detections of Pu-239/240 at the Lysimeter 741-08 location are substantiated by (1) recovery of Pu-239/240 in the laboratory-generated duplicate at a concentration similar to the original analysis result, (2) comparable results from November 2001 and April 2002, and (3) gamma logging data that show significant levels of plutonium, americium, and neptunium in this area.

3.7.2 Vadose Zone

3.7.2.1 Lysimeter Samples at Depths of 0-35 ft. Nine soil moisture samples were obtained from the depth range of 0 to 35 ft and analyzed for Pu-238 and Pu-239/240 in FY 2002, with no positive detections. Historical detections in shallow lysimeter samples are depicted in Figure 3-17 for Pu-238 and Figure 3-18 for Pu-239/240.

FY	Qtr	98-1L35	98-4L38	98-5L39	D15-DL07	PA01-L15	PA02-L16	PA03-L33	W05-L25	W06-L27	W08-L13	W08-L14	W09-L23	W23-L07	W23-L08	W23-L09	W25-L28
1997	1																
	2																
	3							24									
	4																
1998	1							2.2									
	2			5.6		9											
	3																
	4																
1999	1																
	2																
	3																
	4																
2000	1																
	2																
	3		0.9			2.3											
	4						3.7										
2001	1																
	2																
	3																
	4																
2002	1																
	2																
	3																
	4																
Key		Analysis was performed, but Pu-238 was not detected.															
		Pu-238 detected (pCi/L)															
		If more than one positive detection occurred in a single quarter, then only the highest concentration is listed.															
		Note: RBC = 3.64 pCi/L. RBC = 1E-05 risk-based concentration															

Figure 3-17. Occurrences of plutonium-238 in shallow lysimeter samples (detected concentrations in purple).

FY	Qtr	98-1L35	98-4L38	98-5L39	D15-DL07	PA01-L15	PA02-L16	PA03-L33	W05-L25	W06-L27	W08-L13	W08-L14	W09-L23	W23-L07	W23-L08	W23-L09	W25-L28
1997	1																
	2																
	3																
	4																
1998	1																
	2																
	3																
	4																
1999	1																
	2																
	3																
	4																
2000	1																
	2																
	3																
	4																
2001	1						0.7										
	2																
	3																
	4																
2002	1																
	2																
	3																
	4																
Key		Analysis was performed, but Pu-239/240 was not detected.															
		Pu-239/240 detected (pCi/L)															
		If more than one positive detection occurred in a single quarter, then only the highest concentration is listed. Note: RBC = 3.53 pCi/L. RBC = 1E-05 risk-based concentration															

Figure 3-18. Occurrences of plutonium-239/240 detections in shallow lysimeters since FY 1997.

3.7.2.2 Lysimeter Samples at Depths of 35 to 140 ft. Twelve soil moisture samples were obtained from the depth range of 35 to 140 ft in FY 2002 and analyzed for Pu-238 and Pu-239/240, with no positive detections. Historical detections are shown in Figure 3-19 for Pu-238 and Figure 3-20 for Pu-239/240.

3.7.2.3 Lysimeter and Perched-water Samples at Depths Greater than 140 ft. One perched water sample and seven soil moisture samples were obtained in FY 2002 from depth ranges greater than 140 ft and analyzed for Pu-238 and Pu-239/240, with no positive detections. The perched water sample was collected from USGS-92 in January 2002. Four samples were collected in April 2002 from Lysimeters I2D-DL10, I3D-DL12, I4D-DL14, and O8D-DL29. Three samples were collected in July 2002 from Lysimeters I3D-DL12, O6D-DL26, and O7D-DL27.

FY	Qtr	D06-DL01	D06-DL02	D15-DL06	I1S-DL09	I2S-DL11	I3S-DL13	I4S-DL15	I5S-DL16	O2S-DL20	O3S-DL22	O4S-DL24	O5S-DL25	O7S-DL28	TW1-DL04
1997	1														
	2														
	3														
	4	11.6	3.3	3.1											
1998	1														
	2														
	3														
	4														
1999	1														
	2														
	3														
	4														
2000	1														
	2														
	3														
	4														
2001	1														
	2														
	3														
	4														
2002	1														
	2														
	3														
	4														
Key		Analysis performed, but Pu-238 was not detected													
		Pu-238 was detected (pCi/L)													
		If more than one positive detection occurred in a single quarter, then only the highest concentration is listed.													
		Note: RBC = 3.64 pCi/L. RBC = 1E-05 risk-based concentration													

Figure 3-19. Occurrences of plutonium-238 detections in intermediate-depth lysimeters since FY 1997.

FY	Qtr	D06-DL01	D06-DL02	D15-DL06	I1S-DL09	I2S-DL11	I3S-DL13	I4S-DL15	I5S-DL16	O2S-DL20	O3S-DL22	O4S-DL24	O5S-DL25	O7S-DL28	TW1-DL04
1997	1														
	2														
	3														
	4			1.1											
1998	1														
	2														
	3														
	4														
1999	1														0.34
	2														
	3														
	4														
2000	1														
	2														
	3														
	4														
2001	1											3.3			
	2														
	3														
	4														
2002	1														
	2														
	3														
	4														
Key		Analysis performed, but Pu-239/240 was not detected													
		Pu-239/240 was detected (pCi/L)													
If more than one positive detection occurred in a single quarter, then only the highest concentration is listed. Note: RBC = 3.53 pCi/L. RBC = 1E-05 risk-based concentration															

Figure 3-20. Occurrences of plutonium-239/240 detections in intermediate depth lysimeters since FY 1997.

3.7.3 Aquifer

Sixty-three aquifer samples were collected from 15 RWMC monitoring wells in FY 2002 and analyzed for Pu-238 and Pu-239/240, with no positive detections. Occurrences of Pu-238 and Pu-239/240 in aquifer samples since FY 1997 are depicted in Figures 3-21 and 3-22, respectively.

FY	Qtr	A11A31	M10S	M11S	M12S	M13S	M14S	M15S	M16S	M17S	M1S	M3S	M4D	M6S	M7S	OW-2	RWMC Prod	USGS- 127
1997	1																	
	2																	
	3																	
	4																	
1998	1																	
	2																	
	3																	
	4																	
1999	1																	
	2																	
	3													0.044				
	4																	
2000	1																	
	2																	
	3																	
	4																	
2001	1		0.018	0.030							0.019	0.366	0.028		0.071			
	2													0.17				
	3																	
	4								0.034									
2002	1																	
	2																	
	3																	
	4																	
Analysis performed but Pu-238 not detected.																		
Pu-238 detected (pCi/L).																		
Key																		
If more than one positive detection occurred in a single quarter, then only the highest concentration is listed.																		
Note: MCL = 15 pCi/L total alpha.																		
MCL = maximum contaminant level																		

Figure 3-21. Occurrences of plutonium-238 detections in aquifer samples collected around the Radioactive Waste Management Complex since FY 1997.

FY	Qtr	A11A31	M10S	M11S	M12S	M13S	M14S	M15S	M16S	M17S	M1S	M3S	M4D	M6S	M7S	OW-2	RWMC Prod	USGS- 127
1997	1																	
	2																	
	3																	
	4																	
1998	1																	
	2																	
	3																	
	4																	
1999	1																	
	2																	
	3																	
	4																	
2000	1																	
	2																	
	3																	
	4											0.09						
2001	1																	
	2																	
	3																	
	4																	
2002	1																	
	2																	
	3																	
	4																	
Analysis performed but Pu-239/240 not detected.																		
Pu-239/240 detected (pCi/L).																		
Key																		
If more than one positive detection occurred in a single quarter, then only the highest concentration is listed.																		
Note: MCL = 15 pCi/L total alpha.																		
MCL = maximum contaminant level																		

Figure 3-22. Occurrences of plutonium-239/240 detections in aquifer samples collected around the Radioactive Waste Management Complex since FY 1997.

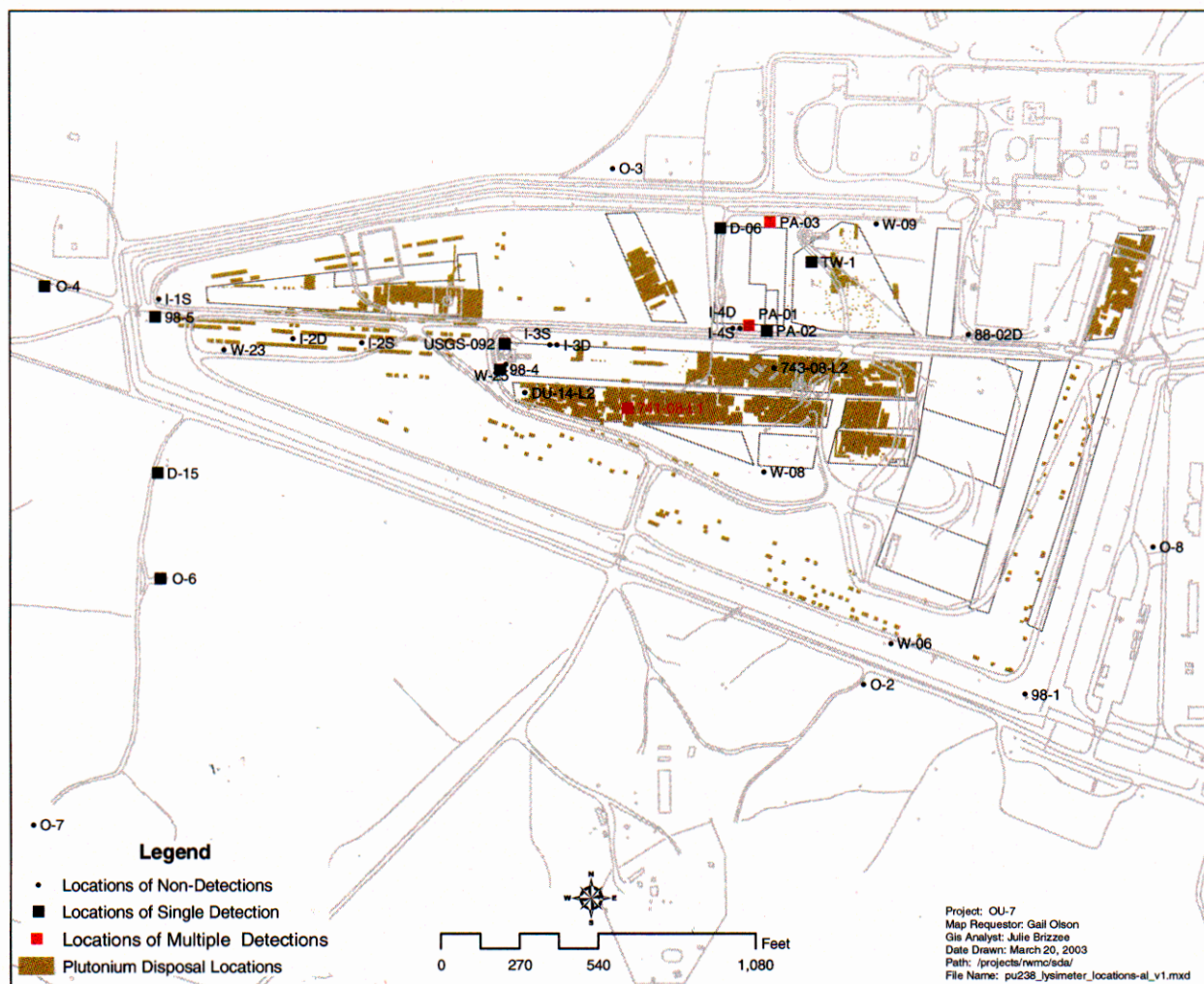


Figure 3-23. Plutonium disposal locations and vadose zone detection locations at the Subsurface Disposal Area.

3.7.4 Summary of Plutonium

No positive Pu-238 or Pu-239/240 detections were associated with SDA vadose zone soil moisture samples or RWMC aquifer samples in FY 2002. Plutonium-239/240 was detected in two soil moisture samples collected from the waste zone in the Americium/Neptunium Focus Area of Pit 10 (see Table 2-3). The locations of historical plutonium detections in the vadose zone are depicted in Figure 3-23, with locations of plutonium-containing disposals. Plutonium detections do not occur in a discernable pattern that would be useful for modeling.

Plutonium-239/240 was not detected more than once in any soil moisture samples since FY 1997. Plutonium-238 was detected more than once in two lysimeters (PA01 and PA03), which are both near Pad A. Lysimeter PA01 is 4.3 m (14 ft) deep located just north of known disposals in Pits 4 and 6. Lysimeter PA03 is 3 m (10 ft) deep and is located just north of Pad A, with no known plutonium disposals nearby. Plutonium has not been detected in Lysimeter PA03 since FY 1998 until the lysimeter was damaged in FY 2000.

Contrary to expectations, most plutonium detections are Pu-238 rather than Pu-239/240. Of the eight plutonium detections in the shallow vadose zone since FY 1997, seven were Pu-238 and only one was Pu-239/240. Plutonium-238 is associated with nuclear fuel rather than RFP weapons-related waste. In contrast, most of the plutonium-containing disposals are documented as originating from RFP, which would contain proportionately more Pu-239/240. The predominance of Pu-238 detections instead of Pu-239/240 suggests there could be more disposals of INEEL reactor operations waste than documented.

3.8 Strontium-90

Strontium-90 is generated by nuclear reactor operations. Approximately $6.44\text{E}+05$ Ci of Sr-90 was disposed of in the SDA, mostly from INEEL reactor operations and subassembly hardware. Carcinogenic risk of Sr-90 is primarily through a surface exposure pathway (e.g., crop ingestion).

3.8.1 Waste Zone

Waste zone soil moisture samples are not analyzed for Sr-90.

3.8.2 Vadose Zone

No soil moisture samples from the vadose zone lysimeters were analyzed for Sr-90. Historical detections of Sr-90 in shallow lysimeters are shown in Figure 3-24. One perched water sample was obtained from the more than 140-ft depth range and analyzed for Sr-90 in FY 2002, but no Sr-90 was detected. The perched water sample was collected from Well USGS-92 in January 2002.

One detection of Sr-90 occurred in the intermediate-depth lysimeters since monitoring for it began in 1997. The detection of 4.1 ± 1.2 pCi/L occurred in Lysimeter TW1-DL04 in November 1998.

3.8.3 Aquifer

Sixty-three aquifer samples were collected from 15 RWMC monitoring wells and screened for Sr-90 activity in FY 2002 using gross beta analysis. Seventeen sample results exceeded the gross beta trigger level of 5 pCi/L and were analyzed for Sr-90, with no positive detections. The trigger level of 5 pCi/L is set below the MCL of 8 pCi/L. Samples were collected in November and December 2001, and February, May, and September 2002, from monitoring Wells A1A31, M1S, M3S, M4D, M6S, M7S, M11S, M12S, M13S, M14S, M15S, M16S, M17S, OW2, and USGS-127.

The gross beta activities measured in all aquifer-monitoring wells around the RWMC were typical of concentrations normally found in the SRPA, with the exception of Well M4D. Well M4D gross beta activity has been consistently higher than gross beta levels observed in all other monitoring wells at the RWMC and has remained relatively constant throughout the past 10-year monitoring period. The gross beta activity for Well M4D is consistently around 23 pCi/L, whereas all other RWMC monitoring wells are about 4 pCi/L. Thus far, no specific beta-emitting radionuclides have been identified as being responsible for the elevated gross beta levels. Because Well M4D is much deeper than other RWMC aquifer monitoring wells (i.e., 244 versus approximately 198 m [838 versus approximately 650 ft]), the higher gross beta activity may be because of higher levels of naturally occurring radioactivity at the deeper levels.

The gross beta activity measured in the sample collected from Well M16S in September 2002 was 26.3 pCi/L, which was above aquifer background levels and drinking water MCLs for Sr-90, but no Sr-90 was detected. All previously measured gross beta concentrations from Well M16S have been consistent with aquifer background levels, and newly obtained data from the first FY 2003 sampling event show gross beta to once again be consistent with aquifer background levels.

FY	Qtr	98-1L35	98-4L38	98-5L39	D15-DL07	PA01-L15	PA02-L16	PA03-L33	W05-L25	W06-L27	W08-L13	W08-L14	W09-L23	W23-L07	W23-L08	W23-L09	W25-L28
1997	1																
	2																
	3																
	4									52							
1998	1																
	2																
	3																
	4																
1999	1																
	2																
	3																
	4																
2000	1	2.2															
	2	3.5	3.5					3.8									
	3														3.8		
	4						8.9										
2001	1																
	2																
	3																
	4																
2002	1																
	2																
	3																
	4																
Key		Analysis was performed, but Sr-90 was not detected.															
		Sr-90 detected (pCi/L).															
If more than one positive detection occurred in a single quarter, then only the highest concentration is listed.																	
MCL = 8 pCi/L																	
MCL = maximum contaminant level																	

Figure 3-24. Occurrences of strontium-90 in shallow lysimeter samples since FY 1997.

3.8.4 Summary of Strontium-90

No Sr-90 was detected in SDA vadose zone soil moisture samples or in RWMC aquifer samples in FY 2002. Historical detections of Sr-90 in the vadose zone are shown in Figure 3-25 along with the known disposal locations. Lysimeter 98-1L35, the only lysimeter where Sr-90 has been detected more than once, is located at the southeast corner of the SDA and not near any known disposal locations. The Sr-90 detections are sporadic and not indicative of emerging trends. Because Sr-90 detections are sporadic, the data probably are not useful to support modeling assumptions and calibration.

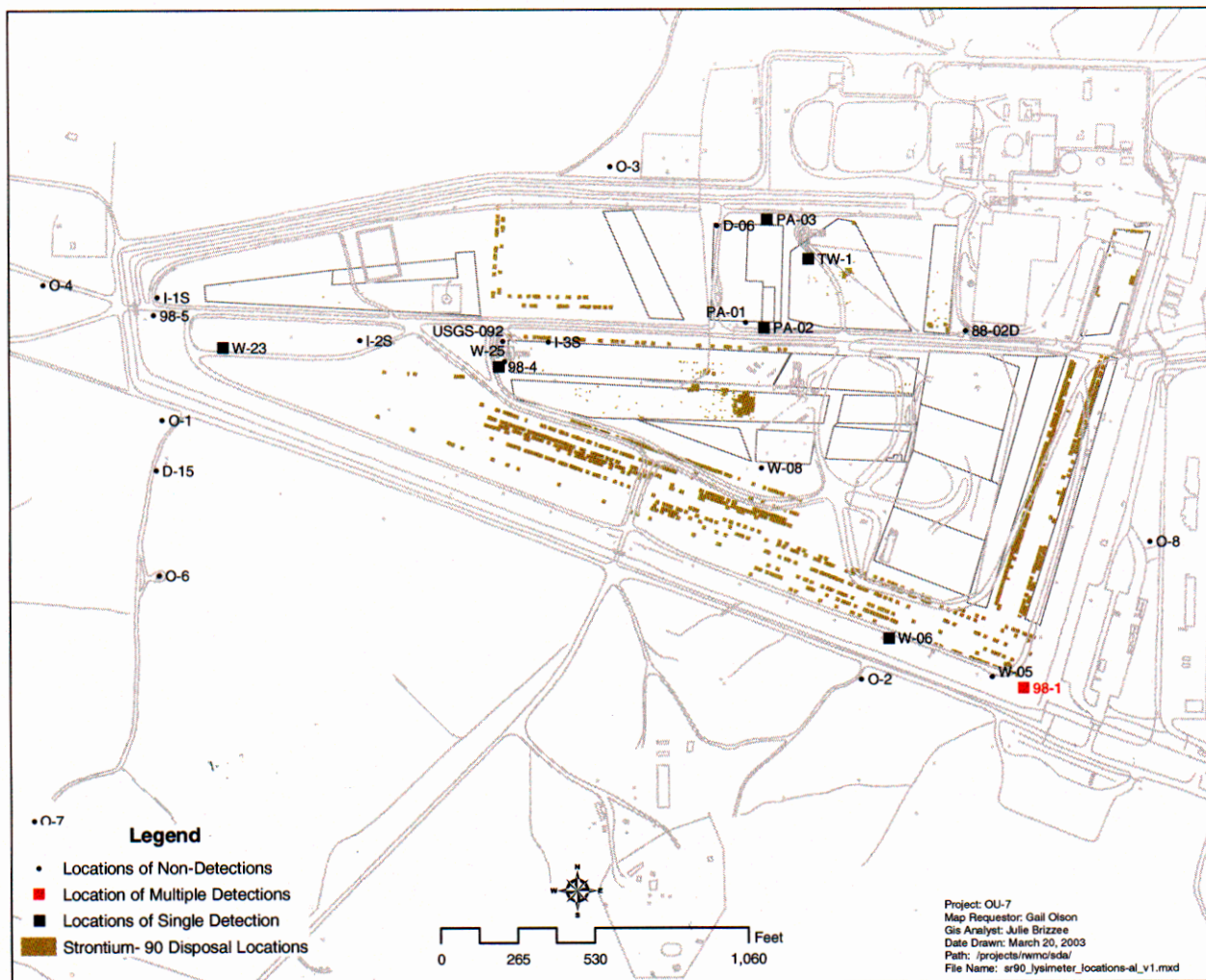


Figure 3-25. Strontium-90 disposal locations and vadose zone detection locations at the Subsurface Disposal Area.

3.9 Technetium-99

Technetium-99 is generated primarily by nuclear reactor operations. Approximately 61 Ci of Tc-99 were disposed of in the SDA. Most originated from INEEL reactor operations waste.

3.9.1 Waste Zone

No waste zone soil moisture samples were collected and analyzed for Tc-99 in FY 2002 because of arid conditions, limited sample volumes, and analytical priorities.

3.9.2 Vadose Zone

3.9.2.1 Lysimeter Samples at Depths of 0 to 35 ft. Five soil moisture samples were obtained in FY 2002 from the depth range of 0 to 35 ft and analyzed for Tc-99, with no positive detections. Historical detections of Tc-99 in the shallow vadose zone are shown in Figure 3-26.

The Tc-99 analysis result of soil moisture collected from Lysimeter W23-L09 in FY 2002 was qualified as a questionable detection (J-flagged) because of contamination detected in the blank; however, the detection was greater than 3σ and samples from this lysimeter typically contain detectable Tc-99 (see Figure 3-26). Technetium-99 appears to be migrating in the soil moisture of the vadose zone at that location.

FY	Qtr	98- 1L35	98- 4L38	98- 5L39	D15- DL07	PA01- L15	PA02- L16	PA03- L33	W05- L25	W06- L27	W08- L13	W08- L14	W09- L23	W23- L07	W23- L08	W23- L09	W25- L28
1997	1																
	2																
	3															17	
	4															30	
1998	1																
	2																
	3																
	4															20	
1999	1						13	36									
	2																
	3																
	4																
2000	1							21									
	2							17								20	
	3	16		21		17					15				39	33	
	4					27											
2001	1																
	2																
	3														46		
	4																
2002	1																
	2																
	3																
	4																
Key		Analysis was performed, but Tc-99 was not detected.															
		Tc-99 detected (pCi/L.)															
		If more than one positive detection occurred in a single quarter, then only the highest concentration is listed.															
		Note: RBC = 173 pCi/L.															
		RBC = 1E-05 risk based concentration															

Figure 3-26. Occurrences of technetium-99 detections in shallow lysimeters since FY 1997.

3.9.2.2 Lysimeter Samples at Depths of 35 to 140 ft. Ten soil moisture samples were obtained from the depth range of 35 to 140 ft and analyzed for Tc-99 in FY 2002, with no positive detections. One sample was collected in April 2002 from Lysimeter I1S-DL09, and nine samples were collected in July 2002 from Lysimeters D06-DL02, D15-DL06, I1S-DL09, I2S-DL11, I3S-DL13, I4S-DL15, O3S-DL22, O4S-DL24, and O5S-DL25. Three unconfirmed Tc-99 detections in lysimeter samples have been made from this depth interval since FY 1997 (i.e., Lysimeters D06-DL01, D06-DL02, and D15-DL06).

3.9.2.3 Lysimeter and Perched-water Samples at Depths Greater than 140 ft. One perched water sample and three soil moisture samples were obtained from depths greater than 140 ft and

analyzed for Tc-99 in FY 2002, with no positive detections. The perched water sample was collected from USGS-92 in January 2002, and three soil moisture samples were collected in July 2002 from Lysimeters I3D-DL12, O6D-DL26, and O7D-DL27. Three unconfirmed detections of Tc-99 have occurred in vadose zone well samples deeper than 140 ft since monitoring began in 1997, all from Well USGS-92. Technetium-99 was detected in the filtered sediment portion of two samples since FY 1997 (December 1998 and September 2000). Both detections were less than 4 pCi/L. Technetium also was detected in the liquid portion of the sample at 280 pCi/L (September 2000).

3.9.3 Aquifer

Sixty-three aquifer samples were collected from 15 RWMC monitoring wells and analyzed for Tc-99 in FY 2002, with one positive detection (see Table 3-17). Occurrences of Tc-99 in aquifer samples since FY 1997 are depicted in Figure 3-27.

Table 3-17. Technetium-99 detections in Radioactive Waste Management Complex aquifer monitoring wells.

Well	Sample Date	Radionuclide	Detected Concentration $\pm 1\sigma$ (pCi/L)	Reanalysis Result ^a $\pm 1\sigma$ (pCi/L)	MDA (pCi/L)	MCL (pCi/L)	Sample Identifier ^b
M7S	2/19/02	Tc-99	1.2 \pm 0.3	Not applicable	0.96	900	RISM3401U7

a. A sample is reanalyzed if the analytical result for Am-241, Np-237, Pu-238, or Pu-239/240 is greater than its sample-specific MDA and greater than two times its reported 1σ standard deviation. The reanalysis provides information necessary to help evaluate and confirm detections.

b. The limitations and validation report identifier associated with the sample identifier is DNT-091-02.

MDA = minimum detectable activity

MCL = maximum contaminant level

3.9.4 Summary of Technetium-99

Of the 19 samples collected in the vadose zone and perched water in FY 2002, only one was a questionable detection (i.e., J-flagged). It was obtained from Lysimeter W23-L09 in July 2002. Though this detection was qualified as questionable, this lysimeter has exhibited a 5-year history of positive Tc-99 detections (see Figure 3-26). Locations of historical Tc-99 detections in the vadose zone are shown on Figure 3-28 along with the locations of disposals containing Tc-99. As shown, Well W23 is located at the west end of the SDA where there are no noted disposals, but where uranium is increasing over time in the soil moisture samples (see Section 3.10). Technetium-99 was detected in a few other shallow soil moisture samples before FY 2002, with most of the detections occurring in FY 2000 (see Figure 3-26).

One out of 63 aquifer samples collected in FY 2002 contained detectable Tc-99. Detections of Tc-99 occur sporadically in the aquifer (see Figure 3-27) and are not indicative of trends or widespread contamination.

The consistent detections of Tc-99 at a depth of 2.3 m (7.7 ft) in W23-L09 combined with higher concentrations in the same well at 3.6 m (11.8 ft) suggest that Tc-99 might be a useful modeling target; however, the inventory records do not indicate that Tc-99 is present in the west end of the SDA. Because the current source release model is based on inventory records, this currently precludes use of this location for calibration.